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Crop Profile for Rutabaga in Canada, 2010

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Canada

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Preface

National crop profiles are developed under the Pesticide Risk Reduction Program (PRRP), a joint program of Agriculture and Agri-Food Canada (AAFC) and the Pest Management Regulatory Agency (PMRA) of Health Canada. The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticides or pest control techniques discussed is implied. Product names may be included and are meant as an aid for the reader, to facilitate the identification of pesticides in general use. The use of product names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

For detailed information on growing rutabaga, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

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Crop Profile for Rutabaga in Canada

The rutabaga (*Brassica napus var. napobrassica,*) is a member of the Cruciferae family. The plant is a cross between turnips (*Brassica rapa*) and cabbage (*Brassica oleracea*) and originated in Scandanavia or Russia in the 17th century. Rutabaga was introduced into North America by European immigrants in the early 19th century. The rutabaga root consists of both a true root and true stem. The upper portion of the stem forms a neck, which distinguishes rutabagas from turnips. The rutabaga is a biennial plant, requiring two years to complete its entire life cycle, from seed to seed. However, only one growing season is required for the production of the edible root, which is the commercial product.

Crop Production

Industry Overview

Rutabaga stores well and is available year round. The root is used as a vegetable for human consumption and has historically been used for animal feed. The crop is also used as filler in foods such as mincemeat. Rutabaga is relatively low in calories and is a good source of vitamin C, folacin and fibre.

The Pesticide Risk Reduction Program currently has an active risk reduction strategy underway for cabbage maggot on crucifers.

Figures on national production and value of the crop are presented in table 1.

Table 1: National production statistics for rutabaga and turnip

Canadian Production (2010)	46,731 metric tonnes 1,836 hectares
Farm gate value (2010)	$18.8 million
Domestic consumption (2010)	0.58 kg/person
Export (2010)	nil
Imports (2010)	nil
Source: Statistics Canada. Fruit and Vegetable Production Catalogue No. 22-003-x, February 2011	

Production Regions

Rutabaga is grown commercially in a number of provinces in Canada. The majority of production takes place in Ontario, Quebec and Prince Edward Island (refer Table 2).

Table 2: Distribution of rutabaga and turnip production in Canada

Production Regions	Planted Area 2010 (hectares)	Percent National Production
British Columbia	104	5.7%
Ontario	694	37.8 %
Quebec	503	27.4%
New Brunswick	34	1.9%
Nova Scotia	76	4.1%
Prince Edward Island	242	13.1%
Newfoundland	82	4.5%
Canada	1,836	100%

Source: Statistics Canada. Fruit and Vegetable Production Catalogue No. 22-003-x, February 2011

For reference, a map of the Canadian major and minor crop field trial regions is presented in figure 1.

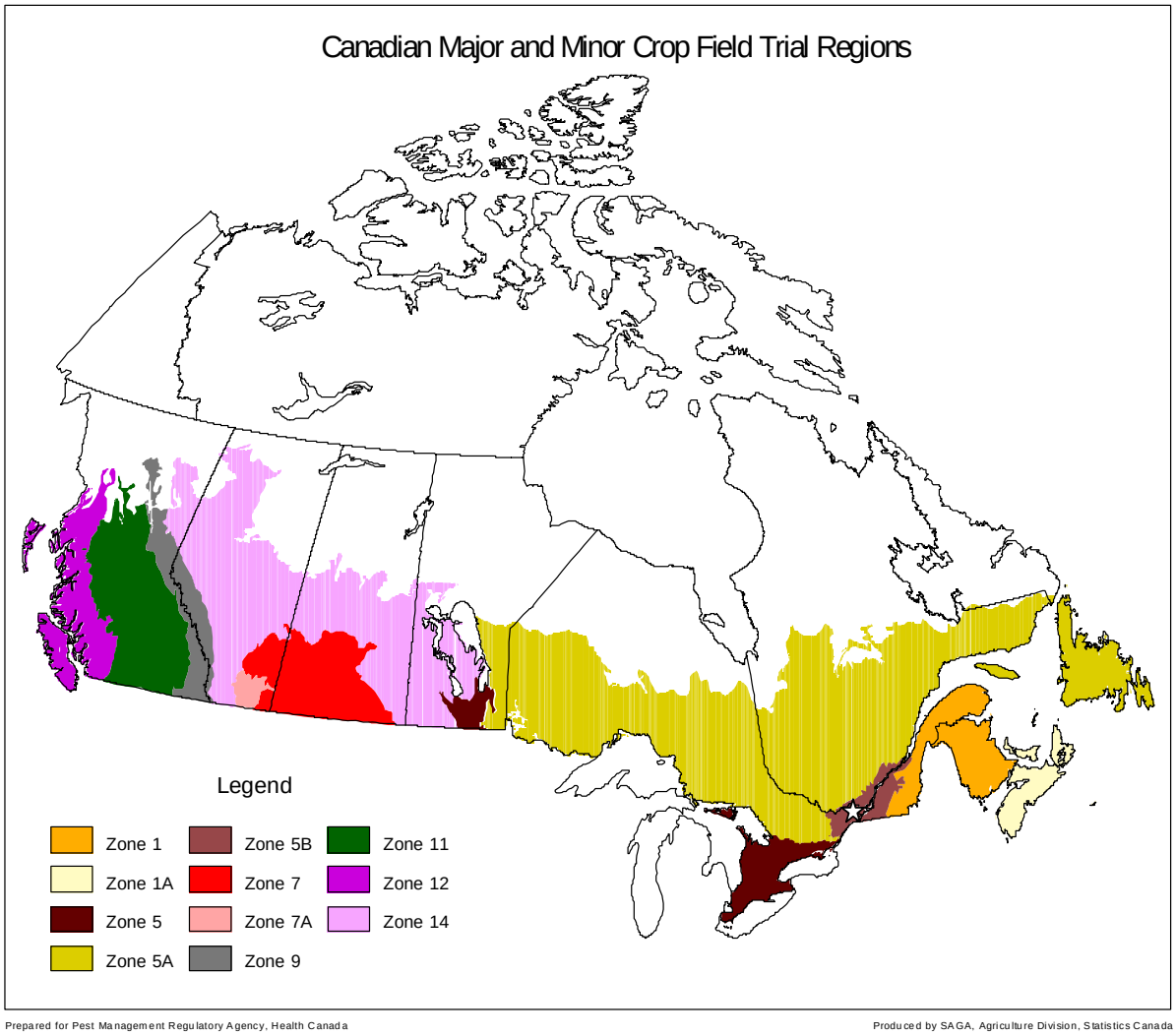

Figure 1: Common zone map: Canadian major and minor field trial regions

The major and minor crop field trial regions were developed following extensive stakeholder consultation and have been harmonized between the Pest Management Regulatory Agency (PMRA) of Health Canada and the Environmental Protection Agency of the USA. The identified regions are used for experimental studies in support of residue chemistry data requirements for the registration of new pesticide uses. The regions are based on soil type and climate and do not correspond to plant hardiness zones. For additional information, please consult the PMRA Directive 98-02 Residue Chemistry Guidelines (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir98-02/index-eng.php).

Cultural Practices

Rutabaga grows best on moderately acidic, well-drained clay loam soil with good tilth and organic matter. Soils that have good drainage are essential for fall or winter harvest. The crop will also grow well on moderately acid loams and sandy loams. On sandy loams, roots tend to elongate, especially in dry weather and with high plant populations. Rutabaga is rarely grown in sandy soils because the coarse sand grains can be abrasive and cause injury to the root tissues. Wounded roots do not keep well during long-term storage. Soil crusting can be a problem on heavy soils in fields with poor rotation (i.e. a rotation which does not provide sufficient organic matter) because the crust can prevent the cotyledons from breaking through the soil surface.

A minimum of four to five years of crop rotation away from cole crops is necessary for acceptable insect and disease control. At least a seven-year rotation may be required in fields infested with the clubroot pathogen. During this period, cruciferous weeds should also be controlled, as they can serve as hosts for clubroot. Rutabaga should follow stubble (cereal crop plow down) instead of sod from perennial legumes such as alfalfa or clover, to reduce the potential for the development of diseases and damage from pests that thrive in sod (eg. wireworms and slugs). Only limited nitrogen is required for rutabaga growth, and this is easier to manage following stubble than following legumes that fix nitrogen. Using legumes in the rotation for two or more years will improve the soil structure and is beneficial, as long as the rutabaga crop does not immediately follow the legume crop.

When choosing fields for rutabaga production, it is also important to consider the possibility of herbicide carryover. Fields where herbicides applied in previous years, persist in the soil, should be avoided, as crop injury may occur. For example, if herbicides with the active ingredient metribuzin (e.g., used on potato and soybean) were applied the year before, there is a strong possibility of injury to rutabaga.

A soil test is required before seeding or planting to determine fertilizer requirements. The soil must not contain too much nitrogen. Limited nitrogen supply results in slow and steady growth, and improves the shape, size and storage-ability of the root. Fertilizers are best broadcast and incorporated prior to planting. Fertilizer placed too close to the root results in excessive root formation, misshapen roots and consequently high cull rates. Major nutrients to be applied include phosphorus, boron, magnesium and gypsum (sulphur). When necessary, lime should be applied to maintain the soil pH in the range of 6.0 to 6.8.

Rutabaga can be directly seeded in the field or grown from transplants. It is important that growers use high quality certified seed. Seeding can begin as soon as the soil can be worked in the spring. Rutabaga that is intended for storage is planted in early to mid June, allowing the plants to develop during the cool fall weather. Early-seeded crops may not be suitable for fall harvest and storage as they can develop woody parts and have poor quality. The optimum soil temperature for germination is 16 to 19^{o}C; however seeds can germinate in soil temperatures as low as 5^{o}C. A fine smooth seedbed is required for uniform seeding depth. Seeding is done at a rate of 225-500 grams/ha and depth of 0.6-1.5 cm. Seeds are spaced 11-15 cm apart in rows that are spaced 50-90 cm. Wide in-row spacing is used for early production and close spacing is used for producing smaller roots. Spacing affects the root size and the harvest date. Precision seeders are used to space seeds at accurate intervals, eliminating thinning and producing a very uniform crop. Thinning, if required, is normally done when plants are 4-8 cm high.

Transplants can be used for early-market rutabaga production. Transplants are started in late March and set in the field in late April. Short, sturdy transplants should be grown without too much cold, which may promote bolting to seed later in the season. Plastic row covers or floating row covers can be used to increase early growth. There is little difference in terms of maturation in rutabaga varieties, although *Thomson Laurentian* tends to be more vigorous. When growing transplants, they must not be subjected to low light conditions and large differences between day and night temperatures.

Rutabaga is well adapted to cool and humid growing conditions. Temperatures between 15°C and 20ºC favour growth. Although frost tolerant, the plants are not usually left in the ground later than the end of October. Rutabagas can tolerate a limited period of temperatures as low as –3^{o}C; however if a significant frost occurs over a prolonged period (longer than 24 hours), the root may freeze, develop a glazed appearance and be unsuitable for storage or sale. Rutabaga can withstand dry periods with a minimal amount of soil moisture, but will have a slower growth rate in these conditions. Excess water also reduces growth. Cracking of the root may occur with a fast growth rate due to excessive fertilization, wide spacing and hot humid weather. Cracks act as potential entry sites for soft rot bacteria. Weeds can be controlled with frequent shallow (2.5-5 cm) cultivation when the crop is dry. This helps conserve moisture and nutrients for the crop and improves soil aeration.

Harvesting is done only when the plant is mature, as the quality and flavour are best when the roots are fully mature and have been exposed to frosts before harvest. Immature roots have a bitter taste and, if early-seeded rutabagas are left in the field until late fall, the roots tend to become fibrous and woody. Rutabagas are very susceptible to bruising, which leads to the development of rot in storage. Bruising may not be apparent until the crop has been stored for three to four months. Harvesting in warm or wet conditions, or putting wet roots into storage can reduce storage quality by making the crop more susceptible to post-harvest diseases. Roots harvested during dry weather tend to shrivel and soften if the level of humidity is not sufficient in storage. Harvesting can be done by hand or mechanically. Mechanical harvesting can cause bruising to the roots. Therefore, care must be taken to minimize injury, especially for roots intended for long-term storage. Storage of roots for up to nine months over the winter and spring months is possible, but special care must be taken to maintain the quality of the rutabaga during this period. The storage facility and storage containers should be cleaned and disinfected in order to prevent the spread of pathogenic micro-organisms that may cause rots during storage. Optimal storage conditions are air temperatures around 0^{o}C and relative humidity greater than 95%.

The following table (table 3) describes production practices and worker activities for rutabaga throughout the season.

Table 3: General rutabaga production and pest management schedule in Canada

Time of Year	Activity	Action
May	Plant care	Planting (earlier in some areas)
	Soil care	Fertilization and liming
	Disease management	Seed treated with fungicides in some provinces
	Insect & mite management	Seed treated with insecticides in some provinces
	Weed management	Cultivation and pre-emergence sprays
June	Plant care	Monitoring and irrigation (if used)
	Soil care	Topdressing
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Post emergent spraying
July	Plant care	Monitoring and irrigation (if used)
	Soil care	Limited activities
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Limited activities
August	Plant care	Monitoring and irrigation (if used), early harvest
	Soil care	Limited activities
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Limited activities
September/ October	Plant care	Harvest and storage
	Soil care	Cultivation

Source(s): OntarioVegetable Production Recommendations, 2009-2010. Atlantic Provinces Agriculture Services Co-ordinating Committee. Vegetable Crops Production Guide. Publication 1400A, Agdex No. 250/600

Abiotic Factors Limiting Production

Herbicide Sensitivity

Rutabaga is extremely sensitive to the drifting of phenoxy herbicides from nearby applications, such as field-crop weed control. Seedling crops of rutabaga can show little, if any, visible sign of phenoxy herbicide damage. However, trace or even undetected levels of phenoxy herbicide residue can result in an unmarketable crop. When growing rutabagas, it is always important to consider the possibility of herbicide carryover from previous crops. Fields where herbicides from previous years persist in the soil must be avoided, as crop injury may occur. In particular, if herbicides with the active ingredient metribuzin (used on potato and soybean, among other crops) were applied the year before, there is a very strong possibility of crop injury occurring if rutabaga is grown in the same field the following year.

Brown Heart

Brown heart (also known as water-core) is a disorder of the rutabaga root that occurs when there is a deficiency in soil boron available to the plant. Affected roots have brown, discoloured areas that may appear soft and water-soaked. The discolouration varies from light to dark brown, and can be a single area or several smaller areas scattered throughout the centre part of the root. Rutabaga first needs boron at about the five-leaf stage, when the root is just beginning to swell. Granular boron must be applied before or at seeding and be followed by foliar applications. By the time brown heart develops, it is usually too late to correct it with boron applications. Rutabagas grown in soils with less than 0.5 ppm soluble boron are more likely to have brown heart. The cultivar *York* tends to be less susceptible to brown heart than *Thomson Laurentian*.

Soil Moisture

Plants take up boron more easily when there is adequate soil moisture. During dry periods, boron may not be very available to the plant. Soils with higher levels of organic matter tend to hold moisture better than soils with lower levels. In fact, organic matter may be a source of boron in acidic soils. However, a pH of greater than 7.0 can also interfere with boron uptake.

Temperature Extremes and Low Light

Bolting or flowering can be a problem with very early-seeded or transplanted crops. Rutabaga is a biennial plant. It forms a swollen root during the first year of growth and flowering stems in the second year of growth after a cold period. The exposure of transplants to low temperatures

(below 5°C) when they are less than 10 weeks old will trigger the development of flowering stems. The duration of the low temperature period that triggers flowering, varies with the variety being grown. However, as little as 3 to 5 nights with temperatures around 3°C are believed to result in development of flowering stems. Field plantings or seedlings can be affected by low temperatures, but transplants more than 10 weeks old require several nights of freezing temperatures to induce flowering.

Mis-shapen (long cylindrical shaped) roots result from transplants being grown under low light conditions and with large differences between day and night temperatures. It is essential to provide good ventilation during the day to help reduce temperatures when the days are bright and sunny. It would be beneficial to raise temperatures to above 10ºC at night with supplementary heating, but the feasibility and economics of this practice are questionable. Delaying seeding may be useful in growing a crop that is less likely to bolt and will produce better-shaped roots.

General Production Issues

Rutabagas suffer from the same problems as other members of the cabbage family. Insect pests are the most important issues for rutabaga production, with the cabbage maggot being the most damaging pest. The cabbage maggot feeds and tunnels in the roots causing young plants to wilt and die. Even a small amount of feeding on mature rutabaga can lower the grade and reduce marketability of the crop. Controlling the cabbage maggot is the most important factor in producing a quality crop. Other important insect problems include caterpillars that feed on the foliage, aphids that suck the plant sap, causing plant stress, especially in hot and dry seasons, cutworms that sever the seedlings and wireworms that feed on the roots. Several diseases such as damping-off, downy mildew, and black rot will damage rutabagas. Rutabagas are affected by weed competition, for which there are few effective herbicides registered. Several physiological disorders also affect rutabagas, including brown heart caused by boron deficiency.

Diseases

Key Issues

- There is a need to register new fungicides for diseases including clubroot, rhizoctonia diseases and downy mildew for disease control and for resistance management..
- The development of varieties with resistance to all races of clubroot would be of benefit.
- There is concern over the spread of clubroot to fields where the disease has not been seen in the past.

Table 4: Occurrence of diseases in rutabaga production in Canada

Diseases	British Columbia	Ontario	Quebec	Nova Scotia	Prince Edward Island	Newfoundland and Labrador
Black leg						
Black rot						D
Clubroot						
Common scab						
Cottony soft rot		F				
Crater rot, wirestem						
Downy mildew						
Powdery mildew						
Root rot		F				
Sclerotium crown rot						
Soft rot/ neck rot		F				
Turnip mosaic virus						
Widespread yearly occurrence with high pest pressure						
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure						
Widespread yearly occurrence with low to moderate pest pressure						
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure						
Pest not present						
DNR - data not reported						
D - Data on distribution was not reported. "Widespread' (worst case scenario) was used for the purposes of colour coding of this cell.						
F - Data on frequency was not reported. "Yearly" (worst case scenario) was used for the purposes of colour coding of this cell.						
[1]Source: Rutabaga stakeholders in producing provinces.						
[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.						

Table 5: Adoption of disease management practices for rutabaga production in Canada

Practice / Pest		Clubroot	Downy mildew	Black rot	Common Scab	Blackleg
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	trap crops - perimeter spraying					
	use of disease-free seed or transplants					
	optimizing fertilization					
	reducing mechanical damage / insect damage					
	thinning / pruning					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	removal of alternative or wild hosts					
	row or plant spacing (plant density)					
	seeding depth					
	water / irrigation management					
	pruning out / elimination of infected crop residues					
Monitoring	scouting - trapping					
	records to track diseases					
	soil analysis					
	weather monitoring for disease forecasting					
	grading out infected produce					
Decision Making Tools	economic threshold					
	weather / weather based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
	calendar spray					
Suppression	biological pesticides					
	beneficial organisms & habitat management					
	environmental management (as in greenhouses)					
	pesticide rotation for resistance management					
	soil amendments					
	controlled atmosphere storage					

Information regarding the practice for this pest is unknown.

This practice is available and used to manage this pest in at least one reporting province.

This practice is not used or is not applicable for this pest in reporting provinces.

Source: Rutabaga stakeholders in producing provinces (BC, ON, QC, NS and NL)

Table 6: Disease control products registered for rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Registration status as of Mar. 31, 2011[3]	Targeted Pests[1]
azoxystrobin	methoxy-acrylate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Rhizoctonia diseases
bacillus-subtilis	Bacillus subtilis and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	Downy mildew
captan	phthalimide	Multi-site contact activity		M4	R	Damping off diseases, root rot (general)
fludioxonil	phenylpyrrole	E2: signal transduction	MAP/Histidine- Kinase in osmotic signal transduction (os-2, HOG1)	12	RE	Seed decay, damping off, seedling blights
fosetyl-Al	ethyl phosphonate	Unknown mode of action		33	RE	Downy mildew
metalaxyl-M	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	Pythium spp
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	RE	Powdery mildew
pyraclostrobin	methoxy-carbamate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Alternaria leaf spot, Cercospora spp., Powdery mildew
sulphur	inorganic	Multi-site contact activity		M4	R	Powdery mildew

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of October 3, 2011. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm ; Insecticides: www.irac-online.org ; Herbicides: http://www.hracglobal.com

[3] R-full registration, RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of March 31, 2011. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details.

Clubroot (*Plasmodiophora brassicae*)

Pest Information

Damage: Diseased plants become chlorotic, are slow to grow and develop, and may partially wilt during warm days. Large, spherical, club-like growths develop below the enlarged area of the root (hypocotyl), which become infected with secondary bacteria, resulting in rot.

Life Cycle: The fungus causing clubroot in rutabagas and cole crops is usually present in areas where these crops have been grown for many years. Land will remain infested for 7 years or longer after a diseased crop. Certain weeds of the mustard family, such as wild radish and wild mustard will maintain or increase the level of infestation year after year. Soils that are cool, wet and acidic (pH less than 7.2) favour the disease. The fungus is soil-borne and is spread by infected seedlings, contaminated manure, water, farm equipment, animals,, human footwear and in soil blown by the wind.

Pest Management

Cultural Controls: Plants should be scouted regularly. A rotation of at least 7 years, that does not include cruciferous crops, should be used once an infestation has been encountered. A 3 year rotation between cruciferous crops can be used on "clean" land. Manure from animals fed infected crops should not be used on land intended for any cruciferous crop. Soil tests should be conducted to ensure that high soil calcium and magnesium levels are maintained along with a pH over 7.2. Planting in fields with a known history of clubroot should be avoided. Field equipment should be disinfected when moved from field to field. Infested land should be seeded to a sod crop, such as hay or pasture, for at least seven years, to prevent the movement of soil. Susceptible weeds should also be controlled.

Resistant cultivars: Resistant cultivars are available; York is resistant to most races of clubroot, while Kingston is resistant to all races. Breeding programs to produce new varieties that are resistant to all races would be of interest.

Chemical Controls: The seedbed can be fumigated if pathogen-free soil is not used.

Issues for Clubroot

1. There is a need for the registration of pesticides for the management of clubroot.
2. Breeding programs for varieties that are resistant to clubroot (all races) would be of benefit.
3. There is some concern over the spread of the disease to fields where the disease has not been seen in the past.

Powdery Mildew (*Erysiphe polygoni*)

Pest Information

Damage: The disease appears as a white, powdery fungal growth on the upper surfaces of leaves which can eventually grow to cover the entire leaf surface and spread to lower leaf surfaces. In advanced stages, leaves turn yellow and die and prematurely drop. This may result in reduced growth and yields and make mechanical harvesting of the crop difficult.

Life Cycle: E. polygoni is a fungal pathogen that occurs in several physiologic races and attacks a wide range of plants. The fungus is spread by wind-blown spores. The fungus over-winters on cruciferous plant debris, weeds and seeds. The disease is more severe under conditions of low relative humidity and water stress within the plant.

Pest Management

Cultural Controls: Dense seeding should be avoided and crop residue should be ploughed under following harvest. Rutabaga fields should be isolated from other crucifers and cruciferous weeds should be controlled. If infections are severe, rotations out of the crucifer family should be used. Monitoring of plants for signs of infection should be done during the growing season.

Resistant cultivars: None available.

Chemical Controls: Refer to Table 6. Disease control products registered for rutabaga production in Canada for fungicides registered for the control of powdery mildew.

Issues for Powdery Mildew

None identified.

Common Scab *(Streptomyces scabies)*

Pest Information

Damage: Scab is a well-known disease of potato and may also cause severe damage to rutabaga. Infection results in circular to oval lesions scattered over the surface of the root which often coalesce to form a corky ring just below the soil line. Affected tissues may consist of a tan, raised layer, or tissues may become pitted and dark following secondary decay. While scab generally does not cause decreases in yield, it can make the affected roots unmarketable.

Life Cycle: S. scabies is a soil-borne bacterium that survives saprophytically on decaying plant material in soil. Host crops for this bacterial pathogen include potato, beet, radish, carrot and parsnip. The bacterium invades rutabaga through lenticels of young tissues and insect feeding wounds. *S. scabies* can be spread by rain and wind blown soil.

Pest Management

Cultural Controls: The pathogen can survive in the digestive tract of animals; therefore, using manure from animals fed contaminated plant material should be avoided in fields intended for growing rutabaga. High lime applications, resulting in high soil pH, may increase the severity of scab. Crop rotations to a non-host crop, such as grass or cereals can be beneficial. The infection is favoured in dry soils; therefore, irrigation can suppress the disease, especially during the period of rapid expansion of the roots.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for Common Scab

None identified.

Rhizoctonia diseases (*Rhizoctonia solani*)

Pest Information

Damage: R. solani causes damping-off, wirestem and root rots of rutabaga and other cruciferous crops. Seeds may rot before germination or seedlings may die and fail to emerge from the soil. Stem infections on small, young plants may result in a dark decay sloughing off of the outer cortex, a symptom commonly called wirestem. On mature roots, root rot lesions (crater rot) may be sunken, spongy and brown with purplish rims that may develop into large

irregular black craters with a scabby appearance. Infection may occur in the field or during storage.

Life Cycle: The pathogen is soil-born and survives the winter as mycelium or sclerotia in soil and plant residues. Infection occurs through wounds and directly through the cuticle. Slow growing seedlings are more susceptible to disease. Field infections may be more severe when the control of root maggot is not adequate. Soil contamination of storage bins can increase the spread and severity of disease in storage.

Pest Management

Cultural Controls: Deep planting and planting into excessively cold or wet soils should be avoided. Poorly-drained fields or fields with a history of crater rot should not be used. Adequate air movement between plants and rotation with grass or cereal green manure crops is important. Insects should be controlled adequately and care must be taken to minimize mechanical injury to the roots during growth. Regular clean up and sterilization of tools and storage bins is important.

Resistant cultivars: None available.

Chemical Controls: There are no fungicides available for field application to control rhizoctonia rot. However, several seed treatments are available. Seed treatments are usually carried out by the seed companies and can keep rhizoctonia problems to a minimum.

Issues for Rhizoctonia rot

1. There is a need for the registration of additional fungicides for rhizoctonia diseases for resistance management.

Blackleg (*Phoma lingam*)

Pest Information

Damage: Blackleg affects many cruciferous crops. Rutabaga may be attacked in seedbeds or in the field. Low levels of seed infection, coupled with weather favourable for disease spread in seedbeds can lead to severe losses after transplanting. Early symptoms of blackleg appear as small spots on leaves of young plants. On stems, the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed, although new roots formed above the lesion may keep the plant alive. Plants may wilt abruptly and die. Cankers may develop on the fleshy roots resulting in a dry rot in storage.

Life Cycle: Blackleg is a destructive fungal disease that can be carried on seed. The pathogen also overwinters on plant debris and on alternate host plants. Small, pin-head size fruiting bodies called pycnidia develop in lesions and release spores that are rain splashed to susceptible plant tissues and cause new infections. Disease may also be spread by worker activity and contaminated equipment.

Pest Management

Cultural Controls: The use of certified disease-free seed and hot-water seed treatments will limit spread of the disease. Work should not be done in the field when plants are wet. Rutabaga should not be planted adjacent to or downwind from fields that were cropped to crucifers or canola in the previous year because water and wind can spread the disease. Manure from animals that have consumed infected plants should not be used. A four year rotation should

be practiced and cruciferous weeds should be continuously destroyed because they may harbour the black leg pathogen.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for Blackleg

None identified

Black Rot (*Xanthomonas campestris* pv. *campestris*)

Pest Information

Damage: Black rot is a very serious disease of cruciferous crops. Infected leaf tissue develops V-shaped, yellow lesions at the leaf margins and chlorosis progresses toward the leaf center, Veins in these areas become dark brown or black. As the infection becomes systemic, symptoms may appear anywhere on the plant and stunting occurs. Blackened vascular tissues may develop in roots.

Life Cycle: The bacterial pathogen can over-winter in plant debris for up to 2 years and be carried internally within the plant and externally on seed. The bacterium infects a range of crucifer crops and weeds. It may be spread in the field by water, insects, equipment, humans and animals. Free water from dew, rain or irrigation is necessary for spread. When spread by water, the pathogen enters water pores at leaf margins or through mechanical injuries. Many outbreaks can be attributed to disease spread in the seedbed. Infested seed is the main vector of black rot, and a seed lot with as few as 5 infected seeds per 10,000 can cause a high incidence of black rot in the field.

Pest Management

Cultural Controls: Work should not be done in the field when plants are wet. Cruciferous weeds should be controlled, as they can be a host for the pathogen that causes black rot. A four year rotation should be followed. Equipment used in an infested field should be cleaned and disinfected before moving to other fields. A hot-water seed treatment (50 °C for 15 minutes) will limit spread of the disease. Only certified, disease free seed should be used. Diseased plants should be removed from the field and destroyed.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for Black Rot

None identified.

Downy Mildew (*Peronospora parasitica*)

Pest Information

Damage: Symptoms include distinct, angular yellow areas on the upper surface of leaves and fluffy, white patches of mycelial growth on the lower surface. Rutabaga roots can be invaded systemically, resulting in internal darkening of the root and in advanced cases resulting in cracks or splitting.

Life Cycle: The disease is favoured by cool moist weather and is a problem on rutabaga in the spring and fall. Temperatures in the range of 10 – 15^{o}C and free moisture on the leaves are

optimal for spore production and initiation of new infections. Spores are spread by wind and splashing rain. The fungus overwinters on seed, in cruciferous weed hosts and likely in soil.

Pest Management

Cultural Controls: Excessive watering of transplants should be avoided. A minimum 3-year crop rotation using grains and grasses should be followed. Seedlings and leaves should be kept as dry as possible. Proper spacing to allow airflow is important. As nutrient deficiencies increase the susceptibility of plants to diseases, fertilization may help the seedlings to outgrow infection.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for Downy Mildew

There is concern over the lack of registered fungicides for this disease, especially in Quebec where the disease is of major importance.

Turnip Mosaic Virus (TuMV)

Pest Information

Damage: Turnip Mosaic virus causes premature yellowing and loss of older leaves on affected rutabaga plants, resulting in a "goose-necked" appearance. Younger foliage may become distorted and mottled. Early season infections result in reduced size of the roots. The loss of leaves makes mechanical harvesting difficult.

Life Cycle: The virus over-winters in living tissues including winter canola crops, some cruciferous weeds, volunteer rutabaga plants and infected rutabaga roots from storage warehouses that are dumped in early spring, The virus is transmitted only by aphids and many species of aphids serve as vectors. The virus is not seedborne.

Pest Management

Cultural Controls: Crops should not be grown near fields of winter canola. Planting should not be done late in the season. Volunteer rutabaga should be controlled and culls should be removed from storage early. Late seeded fields should be isolated from early seeded fields.

Resistant cultivars: None available. Sources of resistant germplasm are being researched and developed.

Chemical Controls: As aphids can acquire and transmit the virus in a relatively short period of time, insecticides to manage the aphid population are ineffective at preventing spread of the virus.

Issues for Turnip Mosaic Virus

None identified.

Root rot (*Pythium* spp. and *Fusarium* spp.)

Pest Information

Damage: Root rots affect rutabaga seedlings at the 2 to 3 leaf stage and result in girdling at the soil surface and death of seedlings. Damage develops quickly at this stage of crop development. Damage can be scattered throughout a field or concentrated in particular area, with no apparent links to soil characteristics.

Life Cycle:

Pest Management

Cultural Controls:

Resistant cultivars: Unknown.

Chemical Controls: Unknown

Issues for root rot

Soft rot / neck rot (*Erwinia carotovora* subsp. *carotovora*, *Pseudomonas* spp.)

Pest Information

Damage: The tops of affected plants appear weak or are easily pulled from the root. Root tissues become soft, rotted and smelly with the exterior of the root remaining intact.

Life Cycle: Soft rot bacteria are present in soil, rotten vegetables and on parts of host plants. They are introduced into rutabagas through wounds caused by insect feeding, dry rot and physiological injuries such as growth cracks or mechanical injury. High temperatures and soil moisture favour soft rot. Severe injury to foliage caused by powdery mildew may also predispose the neck tissues to soft rot. The disease can spread rapidly in storage.

Pest Management

Cultural Controls: The management of soft rot is dependent on preventative measures including following good cultural practices and strict sanitation measures. Cultural practices such as using a 4- 5 year rotation with non-cruciferous crops and non-host crops will help prevent infections in rutabaga. Damaged or infected roots must not be placed into storage. Storages and boxes must be thoroughly cleaned and disinfected prior to being used for a new crop.

Resistant cultivars: None identified.

Chemical Controls: None available.

Issues for soft rot/ neck rot

None identified.

Insects and Mites

Key Issues

- There is a need for the registration of new and safer insecticide products to control insect pests.
- Chlorpyrifos is the only registered insecticide for cabbage root maggot, and is prone to resistance development and under re-evaluation. New insecticides are currently being tested but it is unsure whether or not they will provide effective control of the cabbage root maggot.
- There is a need to promote ongoing research into alternative management strategies for the cabbage maggot (mesh row-cover research is currently ongoing in Atlantic Canada and exclusion fences are being tested in BC).
- More trained personnel are required for integrated pest management delivery.

Table 7: Occurrence of insect pests in Canadian rutabaga production

Insect Pests	British Columbia	Ontario	Quebec	Nova Scotia	Prince Edward Island	Newfound-land and Labrador
aphid (general)						
Cabbage looper						
Cabbage maggot						
Crucifer flea beetle						
Striped flea beetle						
Black cutworm						
Variegated cutworm						
Diamondback moth						
Imported cabbageworm						
Red turnip beetle						
Wireworm						
Widespread yearly occurrence with high pest pressure						
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.						
Widespread yearly occurrence with low to moderate pest pressure						
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure						
Pest not present						
Data not reported						
[1]Source: Rutabaga stakeholders in producing provinces						
[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.						

Table 8: Adoption of insect pest management practices for rutabaga production in Canada

Practice / Pest		Cabbage maggot	Wireworm	Diamondback moth	Imported cabbage worm	Crucifer flea beetle
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	optimizing fertilization					
	reducing mechanical damage					
	thinning / pruning					
	trap crops / perimeter spraying					
	repellents					
	crop rotation					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	removal of alternative hosts (weeds / volunteers)					
	row or plant spacing (plant density)					
	seeding depth					
	water / irrigation management					
	crop residue removal / management					
	pruning out / removal of infested material					
Monitoring	scouting - trapping					
	records to track pests					
	soil analysis					
	weather monitoring for degree day modelling					
	grading out infected produce					
Decision Making Tools	economic threshold					
	weather / weather based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
	calendar spray					
Suppression	biological pesticides					
	environmental management (eg. as in greenhouses)					
	pesticide rotation for resistance management					
	soil amendments					
	ground cover / physical barriers					
	pheromones (eg. mating disruption)					
	sterile mating technique					
	beneficial organisms and habitat management					
	trapping					

Information regarding the practice for this pest is unknown.

This practice is available and used to manage this pest in at least one reporting province.

This practice is not used or not applicable for the management of this pest.

Source: Rutabaga stakeholders in producing provinces (BC, ON, QC, NS, PE and NL).

Table 9: Insect control products registered for rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Registration status as of Mar. 31, 2011[3]	Targeted Pests[1]
carbaryl	Carbamate	Acetylcholinesterase inhibitors	1A	RE	Armyworm, cabbage looper, corn earworm, diamondback moth, imported cabbageworm, lygus bug, meadow spittlebug, six spotted leafhopper, stink bugs
chlorpyrifos	Organophosphate	Acetylcholinesterase inhibitors	1B	R	Black cutworm, cabbage maggot, dark sided cutworm, redbacked cutworm
cypermethrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	Crucifer flea beetle
diazinon	Organophosphate	Acetylcholinesterase inhibitors	1B	R	Aphids, dipterous leafminers, flea beetles, root maggots
endosulfan	Cyclodiene organochlorine	GABA-gated chloride channel antagonists	2A	PO by Dec. 31, 2016	Aphids, cabbage looper, flea beetles, imported cabbageworm
malathion	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	Aphids, cabbage looper, imported cabbageworm, pepper weevil, spider mites
spinetoram	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Cabbage looper, diamondback moth, imported cabbageworm
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Cabbage looper, diamondback moth, imported cabbageworm
trichlorfon	Organophosphate	Acetylcholinesterase inhibitors	1B	DI by Dec. 31, 2013	Beet armyworm, diamondback moth, dipterous leafminers, imported cabbageworm, salt marsh caterpillar, variegated cutworm

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of October 3, 2011. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm ; Insecticides: www.irac-online.org ; Herbicides: http://www.hracglobal.com

[3] R-full registration RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of March 31, 2011. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details.

Cabbage Maggot (*Delia radicum*)

Pest Information

Damage: This insect is the most serious pest of rutabaga in Canada. Larvae or maggots feed by tunnelling into the roots. Plants may be killed, weakened or stunted and yields reduced. Severely infected plants wilt and remain in place in the row, unlike those severed at ground level by cutworms. A small amount of tunnelling in rutabaga roots renders the crop unmarketable.

Life Cycle: There are two to three generations of cabbage maggot per year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring and lay oval shaped, white eggs at the base of the stem of host plants or in nearby crevices in the soil. Eggs hatch in three to seven days.

Pest Management

Cultural Controls: The rutabaga crop should not be grown near other cruciferous crops. Early and late rutabaga should not be grown in close proximity to each other. Crop rotation should be used. Many naturally occurring beneficial insects can help to control populations of cabbage maggot. In Newfoundland and Labrador the beetle, *Aleochara bilineata*, kills a large number of pupae and feeds on eggs.

Resistant cultivars: There are a few less susceptible varieties on the market, but very few resistant varieties have been developed.

Chemical Controls: Refer to Table 9. Insect control products registered for rutabaga production in Canada.

Issues for Cabbage Maggot

1. There is a need for the development of alternative approaches to the management of cabbage maggot in rutabaga.
2. There is a critical need for the registration of reduced risk insecticides for the management of cabbage maggot to replace organophosphate insecticides and for resistance management.

Crucifer Flea Beetle (*Phyllotreta cruciferae*) and striped flea beetle (*Phyllotreta striolata*)

Pest Information

Damage: Adult beetles feed on cotyledons and young leaves of emerging seedlings creating small “shot holes”. Heavy feeding will kill seedlings and if extensive in the field, may result in the crop having to be re-seeded. The larvae feed on the root and are capable of causing scarring of the root surface. Flea beetles are prevalent mostly in the spring and will attack most crucifers.

Life Cycle: The pest overwinters as adult beetles in leaf litter of hedgerows and headlands around fields. Adults feed on cruciferous weeds and volunteer crops until the host crop emerges. There is generally one generation per year. Hot sunny weather favours the adult beetles and damage is most severe during such periods. The adult beetles lay eggs in soil near the roots of host plants and larvae feed on plant roots. Pupation occurs in the soil. Emergence of the

next generation of adults begins in July. Adults feed on cruciferous crops at that time and seek overwintering sites in the fall.

Pest Management

Cultural Controls: Early planting should be avoided. High seeding rates can be used to reduce the impact of the beetles. Irrigation can be used during warm periods to drown adults. There are few natural predators of the flea beetle. Some wasps will feed on the beetle but not enough for complete control.

Resistant cultivars: The variety "American purple top" has some resistance to the flea beetle.

Chemical Controls: Please refer to Table 9. Insect control products registered for insect control in rutabaga in Canada, for products registered against flea beetles. Drenches applied for cabbage maggot will also help to control flea beetles and additional foliar sprays are often not necessary.

Issues for Flea Beetle

1. Flea beetles are present every year and their populations seem to be increasing. Plants are very susceptible from the cotyledon to the 2-3 leaf stage. Currently registered pesticides have good efficacy, however there is a need for the registration of an insecticide for use at the first stages of crop growth.

Diamondback Moth Larva (*Plutella xylostella*)

Pest Information

Damage: Diamondback moth larvae feed on the leaves of rutabaga with early instars mining the leaves and older larvae feeding on lower leaf surfaces. With severe damage, leaves may develop a silvery appearance. Crowns may occasionally be damaged.

Life Cycle: In most years, this insect does not overwinter in Canada and new infestations result from insects that are blown northward from the US. Larvae of the first generation feed on cruciferous weeds prior to moving onto planted crops. Eggs are laid on foliage of host crops. When feeding is complete, the larvae spin cocoons and pupate on the host crop. This insect can have 3-6 generations per year. Hot, dry conditions can cause populations to explode although under cold, wet conditions this pest is not much of a problem. This pest can appear suddenly in epidemic levels, especially if cabbage fields are nearby.

Pest Management

Cultural Controls: Rutabaga should not be grown near other cruciferous crops. Early and late rutabaga should not be grown in close proximity. Crop rotation and planting the crop as far away from plantings in previous years helps in control. Deep ploughing of field debris late in the season reduces numbers of potentially over-wintering adults. The diamondback moth is preyed upon by several species of wasps, including *Diadegma insulare* and *Microplitis plutaellae*. The bacterial insecticide, *Bacillus thuringiensis* is effective, but moth resistance has been recorded in other countries. The use of pheromone bait traps can help predict the presence of larvae.

Resistant cultivars: None available.

Chemical Controls: Registered insecticides are listed in Table: 9. Insect control products registered for rutabaga production in Canada.

Issues for Diamondback Moth Larva

1. Resistance to registered products is a concern as this pest has the ability to quickly develop resistance to pesticides.
2. There is a need to develop thresholds for bait trap catches.

Imported Cabbage Worm *(Pieris rapae)*

Pest Information

Damage: Injury caused by larvae occurs as large irregular holes chewed in the leaves. Foliage is dirtied with pellets of dark-green excrement.

Life Cycle: Eggs are laid singly on the underside of leaves and give rise to velvety-green larvae. Larvae feed on foliage and when feeding is complete, pupate on the plant or plant debris. Various stages may be seen on the foliage at the same time. There are three to five generations a year. Pupae over-winter attached to old plants or debris. Larvae mature in two to three weeks and pupate; butterflies emerge in one to two weeks.

Pest Management

Cultural Controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga should not be grown in close proximity. There are a number of wasps and flies that prey on the imported cabbageworm. *Bacillus thuringiensis* is a preferred bacterial insecticide. A granulosis virus will cause high mortality rates in the larval stage, but it is not commercially available in Canada.

Resistant cultivars: None available.

Chemical Controls: Insecticides may be used if larvae are causing severe leaf damage.

Issues for Imported Cabbageworm

None identified.

Cabbage Looper (*Trichoplusia ni*)

Pest Information

Damage: Feeding by the cabbage looper results in the leaves being riddled with ragged-edged holes. The growth of severely infested plants is stunted.

Life Cycle: Since the cabbage looper prefers warmer climates, it is only a serious pest in southern regions of Canada where the pest can have as many as three generations per season, as compared to only one in the Atlantic Provinces. Eggs are laid on lower leaf surfaces, close to the edge of the foliage and following larval feeding, pupation occurs on the foliage.

Pest Management

Cultural Controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga should not be grown in close proximity. There are several parasitic wasps, ants, beetles and flies which feed on the larvae and eggs of the cabbage looper. Viruses can be important for control, as the pest is susceptible to many different types. Larvae may be infected by a nuclear polyhedrosis virus; however this virus is not commercially available. *Bacillus thuringiensis* is commercially available and effective.

Resistant cultivars: None available.

Chemical Controls: Chemical sprays can be effectively used. Registered insecticides are listed in Table 9. Insect control products registered for rutabaga production in Canada. .

Issues for Cabbage Looper

None identified.

Wireworm (*Melanotus communis*)

Pest Information

Damage: The larvae feed on roots and seed in the soil.

Life Cycle: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about a week and depending on the species, will live for 1 to 5 years in the ground feeding on roots and seeds. Wireworms require three or more years to complete their life cycle. Wireworms of all sizes and ages are present in the soil throughout the year as there is always an overlapping of generations. Mature larvae pupate in the fall and emerge in the spring as adult beetles. Wireworms are often numerous in soil that has been in sod for several years, however they are also becoming an increasing problem in fields that have been in cultivation for a number of years. They are also more abundant in heavy, poorly drained soil.

Pest Management

Cultural Controls: Fields known to have heavy infestations or fields coming out of sod should be avoided. Rotation with non-host crops should be done to help reduce populations. Bait stations in spring or fall provide a method for checking to see if wireworms are present.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for Wireworm

1. There is a lack of effective controls for wireworms.
2. Improved pest control strategies, including cultural and biological approaches to the management of wireworm, must be developed.
3. There is a need for the registration of new products that will control wireworm, especially for long season root crops like rutabagas, potatoes, and carrots.

Aphids: cabbage aphid (*Brevicoryne brassicae*), green peach aphid (*Myzus persicae*) and turnip aphid (*Lipaphis erysimi*)

Pest Information

Damage: Aphids feed by sucking plant sap. Saliva injected while feeding may introduce plant viruses or may be toxic to the host plant. Feeding by large numbers of aphids causes foliar discolouration, curls leaves and damages developing buds. A sticky substance, called honeydew, is excreted by the aphids and may cover the leaves and crown and result in sooty mould growth.

Life Cycle: In late spring, aphids move from their overwintering hosts to crop plants. The population consists primarily of female aphids that can reproduce without mating and bear live young. At certain times of the year male aphids arise, mating occurs and eggs are

produced. Low populations of some species can quickly increase during warm dry weather and completely colonize the upper parts of the plant.

Pest Management

Cultural Controls: Early and late rutabaga should not be grown in close proximity. Also, rutabaga should be grown as far as possible from corn fields, as corn is an important host of aphids. Naturally occurring predators may suppress aphid numbers, particularly later in the season.

Resistant Cultivars: None available.

Chemical Controls: Chemical sprays are used only if aphids are in high enough numbers to cause wilting of leaves during dry weather or if there is concern about the transmission of viruses. Insecticides registered for the control of aphids are listed in Table 8.

Issues for Aphid

1. There is an urgent need for the registration of new pesticides to control aphids.

Cutworm: Black cutworm (*Agrotis ipsilon*) and variegated cutworm (*Peridroma saucia*)

Pest Information

Damage: Black and variegated cutworms may cause considerable damage to rutabagas. They attack very young plants that have recently emerged from the soil. Later, they also feed on the crown and leave deep scars or burrow into the root. Damage may occur in the spring and also later in the growing season. Late season infestations are difficult to detect and often are not noticed until harvest time.

Life Cycle: Cutworms pass through egg, larval, pupal, and adult stages and depending on the species, can have one or more generations per year. The spring generation is the most damaging because its occurrence coincides with seed germination. The variegated cutworm overwinters as pupae in warmer parts of Canada. The black cutworm is wind blown northward from the US.

Pest Management

Cultural Controls: Fields known to have high numbers of cutworm should be avoided. Fields recently converted from meadowlands have greater risks of infestation...Pheromone baited traps can be used to forecast the presence of larvae.

Resistant Cultivars: None available.

Chemical Controls: Cutworms are normally kept under control by chemicals used for cabbage maggot. Refer Table 8 for insecticides registered for cutworm control.

Issues for Cutworm

None identified.

Red Turnip Beetle (*Entomoscelis americana*)

Pest Information

Damage: Adults and the larvae feed on foliage. Large, ragged holes are chewed in the leaves and frequently, only midribs and stems are left. Heavy damage may occur when large numbers are present. Yield is reduced or the plants may be killed. The red turnip beetle is often considered to be beneficial because it feeds upon and controls cruciferous weeds. It is rare that red turnip beetles cause significant economic damage to crops but when they do, controls should be applied immediately.

Life Cycle: The beetle can feed and survive on many weeds. There is one generation a year. Eggs over-winter in the soil and hatch in early May. Larvae mature by late June and pupate in the soil. Adults emerge and feed for a short time until hot weather causes them to cease feeding and return to the soil. When temperatures are cool in August and September, they re-emerge, feed and lay eggs. Adults remain on the plants until the first killing frost.

Pest Management

Cultural Controls: Weeds in and around fields should be controlled. Volunteer canola and other hosts should not be left in the field. Cultivation in the fall or spring will kill many of the eggs.

Resistant Cultivars: None available.

Chemical Controls: This pest will usually be controlled if a regular root maggot control program is followed. Insecticides registered for the control of the red turnip beetle are listed in Table 9. Insect control products registered for rutabaga production in Canada.

Issues for Red Turnip Beetle

None identified.

Weeds

Key Issues

- There is a need for herbicides that will control weeds of the crucifer family (shepherd's purse, wild radish, etc.)
- There is a need for the registration of herbicides to control annual broadleaf weeds and some grasses such as annual bluegrass.

Table 10: Occurrence of weed pests in rutabaga production in Canada

Weeds	British Columbia	Ontario	Quebec	Nova Scotia	Prince Edward Island	Newfoundland and Labrador
Annual broadleaf weeds						
Redroot pigweed						
Common ragweed						
Shepherd's purse						
Lamb's-quarters			7			
Wormseed mustard						
Lady's thumb						
Wild radish						
Hairy nightshade						
Corn spurry	D					
Annual grass weeds						
Barnyard grass						
Wild oats						
Perennial broadleaf weeds						
Canada thistle						
Scentless chamomile						
Perennial grass weeds						
Quackgrass						

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

Data not reported

D - Data on distribution was not reported. "Widespread' (worst case scenario) was used for the purposes of colour coding for this cell.

[1]Source: Rutabaga stakeholders in producing provinces.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 11: Adoption weed pest management approaches for rutabaga production in Canada

Practice / Pest		Annual grass weeds	Annual broadleaf weeds	Perennial grass weeds	Perennial broadleaf weeds
Avoidance	planting / harvest date adjustment				
	crop rotation				
	choice of planting site				
	use of weed-free seed				
	optimizing fertilization				
Prevention	equipment sanitation				
	mowing / mulching / flaming				
	row or plant spacing (plant density)				
	seeding depth				
	water / irrigation management				
	weed management in non-croplands				
	weed management in non-crop years				
	tillage / cultivation				
Monito-ring	scouting - field inspection				
	field mapping of weeds / record of resistant weeds				
	soil analysis				
Decision Making Tools	economic threshold				
	weather / weather based forecast / predictive model				
	recommendation from crop specialist				
	first appearance of weed or weed growth stage				
	observed crop damage				
	crop stage				
	calendar spray				
Suppression	biological pesticides				
	habitat / environment management				
	pesticide rotation for resistance management				
	soil amendments				
	ground cover / physical barriers				
	inter-row cultivation				
	mechanical weed control				

Information regarding the practice for this pest is unknown.

This practice is available and used to manage this pest in at least one reporting province.

This practice is not used or not applicable for the management of this pest.

Source: Rutabaga stakeholders in producing provinces (BC, ON, QC, NS, PE and NL)

Table 12: Weed control products registered for rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Registration status as of Mar. 31, 2011[3]	Targeted Pests[1]
carfentrazone-ethyl	Triazolinone	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	Annual and perennial weeds
clopyralid	Pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	RE	Common ragweed
EPTC	Thiocarbamate	Inhibition of lipid synthesis - not ACCase inhibition	8	R	Perennial weeds, annual grass weeds, annual broadleaf weeds
fluazifop-P-butyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	RE	Grass weeds
napropamide	Acetamide	Inhibition of cell division (Inhibition of VLCFAs; see Remarks)	15	R	Annual grasses, annual broadleaf weeds
quizalofop-P-ethyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	Annual weeds
s-metolachlor	Chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs; see Remarks)	15	R	Annual and perennial weeds
trifluralin	Dinitroaniline	Microtubule assembly inhibition	3	R	Annual grass weeds, annual broadleaf weeds

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of October 3, 2011. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm ; Insecticides: www.irac-online.org ; Herbicides: http://www.hracglobal.com

[3] R-full registration, RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of March 31, 2011. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details.

Annual and Biennial weeds

Annual grasses: Barnyard grass (*Echinochloa crusgalli*), green foxtail (*Setaria viridis*), volunteer wheat, (*Triticum aestivum*), annual bluegrass (*Poa annua*)

Annual broadleaf weeds: Corn spurry (*Spergula arvensis*), hairy nightshade (*Solanum sarachoides*), hemp nettle (*Galeopsis tetrahit*), kochia (*Kochia scoparia*), lady's thumb (*Polygonum persicaria*), low cudweed (*Gnaphalium uliginosum)*, wild radish (*Raphanus raphanistrum*), volunteer potatoes (*Solanum tuberosum*), wild buckwheat (*Polygonum convolvulus*), hairy galinsoga (*Galinsoga ciliata, G. quadriradiata*), wormseed mustard (*Erysimum cheiranthoides*), March yellow cress (*Rorippa islandica*), shepherd's purse (*Capsella bursa-pastoris*), Scentless mayweed (*Matricaria maritima*)

Pest Information

Damage: Broadleaf weeds can reach heights similar to rutabaga and compete with the crop for light, water and nutrients. If not controlled, they will reduce rutabaga growth and yield. Annual grasses have fast growth and the ability to compete for necessary resources, making them a serious problem. Grass weeds are very tolerant to extremes in moisture and temperature once established. They can be very difficult to eliminate from infested fields and they require management/control prior to seed-set due to their prolific seeding. In rutabagas, the critical stage for control of annual weeds is early in the growing season.

Life Cycle: Annual grass and broadleaf weeds complete their life cycle in one year, going from seed germination through growth to new seed production. Spring annuals germinate in the early spring and grow to produce seed in the summer or fall of the same year. Winter annuals begin their growth in the fall, growing a rosette and producing their seeds early the following year. Annual weeds are very adept at disseminating through the production of large numbers of seeds. Most arable land is infested with annual weed seeds at all times and some weed seeds can remain viable in the soil for many years, germinating when conditions are favourable. Biennial weeds germinate in the spring producing a rosette of leaves and remain vegetative during the first summer. They over-winter as rosettes and then during the second summer they send up a flower stock on which seeds are produced. The original plants then die at the end of the second growing season. Seeds can remain "banked" in the soil for years until conditions favourable for germination occur.

Pest Management for Annuals and Biennials

Cultural Controls: Weeds along road sides, ditches, and fence lines should be controlled by mowing or planting perennial grasses. A site that is as weed free as possible should be selected for growing rutabaga. Fields should be scouted in the previous season to determine what weeds might be expected and to determine if they can be controlled in the rutabaga crop. Purchased seed should be certified to ensure that it contains the lowest possible quantities of weed seed. To reduce the transport of weeds by equipment, soil and debris should be cleaned off when leaving each field. Manure applications may also introduce weeds to a field. Repeated tilling prior to planting and cultivation after planting, will reduce germinating weeds. Monitoring for annual weeds should be done during the first 2-3 weeks after weed emergence if post emergence controls are to be applied. Row spacing should be chosen that favours row closure. Crop rotation can disrupt perennial and biennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Rotating between broadleaf and grassy crops provides a chance to control broadleaf weeds in grassy crops and grassy weeds in broadleaf crops with selective

herbicides. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimize erosion and nutrient loss over the winter.

Resistant cultivars: Choose rutabaga varieties that will give quick emergence and vigorous crop stands that will help shade out germinating weed seeds.

Chemical Controls: Herbicides currently labelled for control in rutabagas work well on annual grasses and a few small seeded broadleaf weeds. Most annual broadleaf and grass weeds can be controlled in rutabagas with a soil applied pre-emergent residual herbicide. This can provide season long protection against germinating weeds and seedlings. Once the rutabagas emerge, there are limited herbicide options for controlling broadleaf weeds in the crop. Selective systemic herbicides can be used to control grass that emerges after the crop plants. Refer to Table 10. Classification and registration status of herbicides available for weed management in rutabagas in Canada.

Perennial Weeds

Perennial grasses: Quackgrass (*Elitrigia repens*)

Perennial broadleaf weeds: Field mint (*Mentha arvensis*), narrow-leaved golden rod (*Solidago graminifolia)*

Pest Information

Damage: Refer to damage description under annual and biennial weeds. Perennial weeds can become very large and be very competitive, especially if they have been established for several years.

Life Cycle: Perennial grass and broadleaf weeds can live for several to many years and generally establish from various types of root systems, although many will also spread by seeds. Perennials usually flower every year as well as expand their root system and can spread effectively by both methods. Most perennial weed seeds germinate in the spring and the plants grow throughout the summer. During this period they also expand their root systems, sending up new plants along the roots as well as expanding the size of existing plants. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds. The critical stage for damage is early in the growing season, as for the other groups of weeds.

Pest Management for Perennials

Cultural Controls: See cultural controls for annual and biennial weeds; Cultivation is less effective at controlling perennial weeds as compared to annual weeds, because of their large root systems. Tillage and cultivation may break up the underground portions of the plant and increase the weed problem.

Resistant cultivars: Rutabaga varieties that give quick emergence and produce vigorous crop stands will help shade out germinating weed seeds.

Chemical Controls: Many perennial broadleaf and grass weeds cannot be effectively controlled once established in the rutabaga crop and must be controlled in the years preceding the rutabaga crop.

Issues for Weeds

Refer to Key Issues section.

Resources

IPM/ ICM resources for production of rutabaga in Canada

Agri-Reseau (http://www.agrireseau.qc.ca)
http://www.agrireseau.qc.ca/rap/navigation.aspx?sid=1186&pid=0&r=
http://www.agrireseau.qc.ca/lab/documents/Crucif%c3%a8res-2001.pdf
http://www.agrireseau.qc.ca/lab/documents/Maladies%20transplants%20crucif%c3%a8res.pdf
http://www.sagepesticides.qc.ca/default.aspx
http://eap.mcgill.ca/agrobio/ab360-12.htm#Dommages

Guide to Pest Management in Turnip and Rutabaga. Nova Scotia Vegetable Crop Guide to Pest Management 2011 [TUR1-11] Rev June 16, 2011. AgraPoint International
http://www.agrapoint.ca/Pest%20Management%20Guides/Vegetables/2011/Rutabaga%202011.pdf

Howard, J.R., Garland J.A., Seaman W.J.1994 *Disease and Pests of Vegetable Crops in Canada.* The Canadian Phytopathological Society and Entomological Society of Canada.

Integrated Pest Management for Crucifers (2008) OMAFRA Publication 701; Agdex #252 available from www.ServiceOntario.ca

Ontario Crop Integrated Pest Management – IPM Training Online
www.omafra.gov.on.ca/IPM/english/index.html

OMAFRA Vegetable Production Information
www.omafra.gov.on.ca/english/crops/hort/cole_crops.html

Turnip and Rutabaga Atlantic Provinces Vegetable Crops Guide to Pest Management 2005 Publication 1400A Agdex No. 250/600 April 2005.
Atlantic Provinces Agricultural Services Coordinating Committee.
http://www.gov.pe.ca/agriculture/index.php3?number=69770&lang=E

Vegetable Production Guide 2010 -2011: Beneficial Management Practices for Commercial growers in British Columbia http://www.agf.gov.bc.ca/cropprot/prodguide.htm

Vegetable Production Recommendations (2009-10) OMAFRA Publication 363); Publication 363SE, Supplement - Vegetable Production Recommendations
2010 - 2011 www.ServiceOntario.ca

Provincial Vegetable Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Vegetable Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture and Lands	Susan Smith , Field Vegetables and Organics Specialist susan.l.smith@gov.bc.ca	Caroline Bédard caroline.bedard@gov.bc.ca
Ontario	Ontario Ministry of Agriculture and Food	Marion Paibomesai, Vegetable Specialist marion.paibomesai@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère d'Agriculture, Pêcheries et Alimentation du Québec	Denis Giroux, agronomist d-giroux@videotron.ca	Pierre-Antoine Thériault pierre-antoine.theriault@mapaq.gouv.qc.ca
Nova Scotia	Nova Scotia Department of Agriculture and Fisheries	-	Lorne Crozier crozielm@gov.ns.ca
	AgraPoint www.agrapoint.ca	Viliam Zvalo, Vegetable Specialist (Kentville) V.zvalo@agrapoint.ca	-
		Rachael Cheverie, Horticulture Specialist (Truro) R.cheverie@agrapoint.ca	-
Prince Edward Island	Prince Edward Island Department of Agriculture		Shauna Mellish smmellish@gov.pe.ca
Newfoundland and Labrador	Department of Natural Resources	-	Leah Madore leahmadore@gov.nl.ca

National and Provincial Vegetable Grower Organizations

Agri-Reseau (http://www.agrireseau.qc.ca)

British Columbia Potato and Vegetable Growers Association (http://www.bcfreshvegetables.com/bcfresh/associations)

Canadian Horticultural Council (http://www.hortcouncil.ca)

Conseil Québecois de l'horticulture (CQH) (http://www.cqh.ca)

Horticulture Nova Scotia (http://hortns.com)

Newfoundland and Labrador Horticultural Producers Council Incorporated (http://www.hortnl.com

Ontario Fruit and Vegetable Growers Association (http://www.ofvga.org)

Prince Edward Island Horticultural Association (peihort@pei.aibn.com)

Appendix 1: Explanation of colour coding of disease, insect and mite and weed occurrence tables (Tables 4, 7 and 10)

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in the Tables 4, 7 and 10, respectively of the crop profile. The colour coding in the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart. (Definitions of terms is provided at the bottom of the table):

Pest Frequency	Distribution	Pest Importance	Colour Code
If the pest is present 7 or more years out of 10 (yearly)	widespread	high	Red
		moderate	Orange
		low	Yellow
	localized	high	Orange
		moderate	White
		low	White
If the pest is present 6 years or less out of 10 (sporadic)	widespread	high	Orange
		moderate	yellow
		low	white
	localized	high	yellow
		moderate	White
		low	White
Pest not present			black
Data not reported			grey

Definition of terms describing pest distribution, frequency and importance:

Distribution: Localized: Present only in limited areas of the province

Widespread: Present throughout the province

Frequency (number of years the pest is present at levels requiring controls)

Sporadic: Present 6 years or less/ 10

Yearly: Present 7 years or more /10

Pest importance (based on crop impact and the need for controls when present)

Low: If present, potential for spread and crop loss is low and controls must be implemented only under specific conditions.

Moderate: If present, potential for spread and crop loss is moderate; pest situation must be monitored and controls may be implemented.

High: If present, potential for spread and crop loss is high and controls must be implemented even for small populations.

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